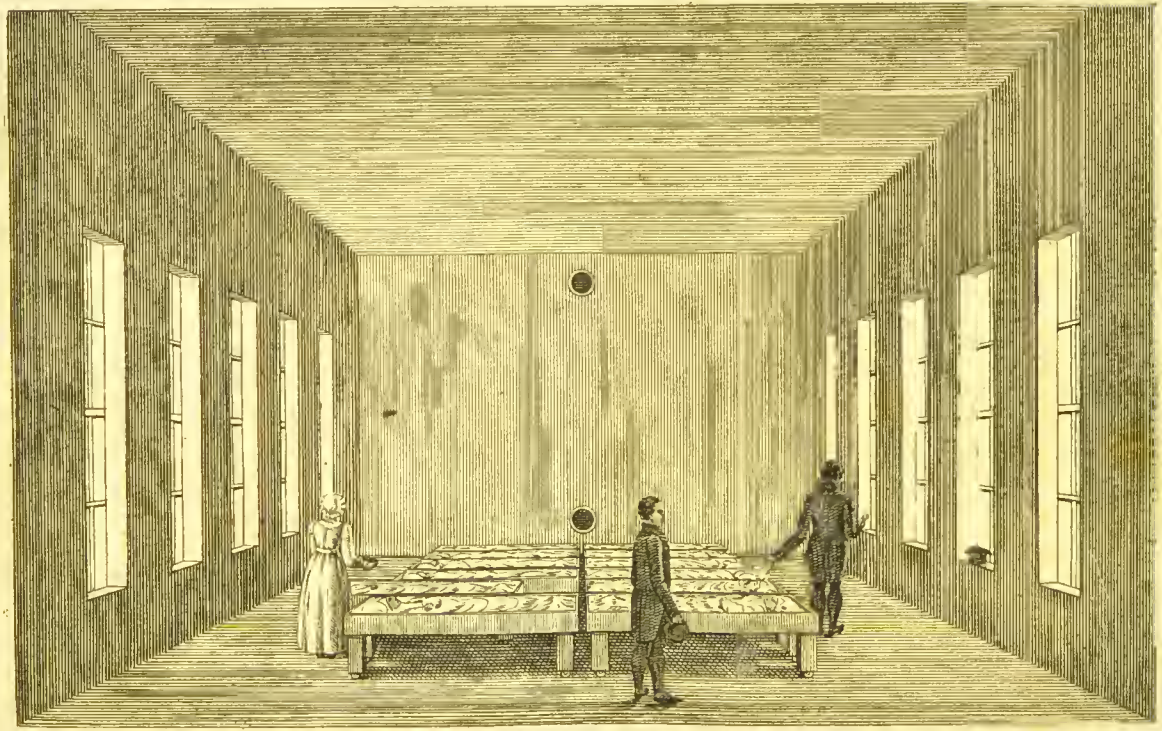
To

ndrew Duncan Esq. M.D.

ofessor of the Theory &
titutes of Medicine
niversity Edinburgh
ith the grateful regards
f the Author.

r Duncan's review of
his treatise will
oblige the Author

VENTILATION.



A VIEW OF THE INTERNAL ARRANGEMENT OF A WARD.

A NEW MODE

OF

VENTILATING

HOSPITALS, SHIPS, PRISONS,

&c. &c.

BEING AN EFFICIENT METHOD OF

DESTROYING CONTAGION,

AND OF PREVENTING THE

SPREADING OF INFECTIOUS DISEASES.

By GEORGE HAWTHORNE, M. D.

"Dum spirat homo lethale sibi aliisque spirantibus venenum fundit."
GREGORII CONSPECT.

BELFAST:

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TO

SIR JAMES M'GRIGOR, KNIGHT.,

M.D. F.R.S. K.T.S.

Director General, Army Medical Board.

SIR,

THE success that attended your learned professional exertions during the late Peninsular war, entitles you to the gratitude and thanks of all His Majesty's subjects; and as I am thoroughly persuaded that you still feel the same solicitude, not only for the welfare of the gallant troops and seamen, who constitute in a high degree the strength and the glory of the empire,

but also for the best interests of society in general, I beg leave respectfully to inscribe to you this work, as a feeble expression of my esteem for your public and private character.

The method of ventilating which it suggests, though very imperfectly described, will, I trust, on perusal, appear to you to be at least worthy of a trial.

Extensive experience, and opportunities of observation on every subject connected with medicine, eminently qualify you for forming an opinion of the efficiency of such a plan, and for judging of the merits or demerits of a work of the kind.

From the rank you hold in society, and the high station you sustain at the head of the Army Medical Department, your

approbation of the work is all that is necessary, not only to secure for it the favourable reception of His Majesty's Government, but to recommend its universal adoption. I have the honour to be,

SIR,

With the greatest respect,

Your obedient and very humble servant,

GEORGE HAWTHORNE.

CLARENCE PLACE, BELFAST,
20*th Nov.* 1828.

PREFACE.

THE mode of ventilating recommended in this Work, I laid before the Public in an abridged form, in two Essays published in the year 1824. I was not at that time aware that any similar plan had ever before been suggested. I have since, however, discovered, that in the year 1665, Sir ROBERT MORAY published a paper in the Philosophical Transactions, recommending the foul air to be drawn off from the holds of ships, by means of pipes, to be operated on by the agency of fire. A similar method was also recom-

mended by a Mr. SUTTON, an eminent Brewer in London. Neither of these plans, however, has ever yet come into general use.

Dr. HALES invented a ventilator, which, for a length of time, was highly extolled as an efficient means of removing foul air from ships and prisons. But the machine, I consider, is much too complicated for general use. It would, besides, require a considerable moving power to keep it working. In short, I can see no just reason why it should be so highly praised, unless it be the fact of its having been successfully kept in motion for some years in Newgate prison by means of a wind-mill. The mere mention of such a circumstance, is all that is necessary to show the absurdity of the means, compared with the simplicity of the plan recom-

mended in this Treatise. While the heat is kept applied to the ventilating tube, it continues its operation without interruption, *even without the assistance of a wind-mill*—it requires no additional labour, and little or no additional expense.

In the present Work, I had intended to point out the best mode of constructing hospitals, and buildings of every kind, with a view to their ventilation. This, on after consideration, I declined, lest it should be made a ground of objection to the mode of ventilating I have recommended.

Had I done so, it might have been said by some, that this plan appears plausible and rational, and might no doubt answer the end, but, to adopt it, we must abandon our old houses, and build new ones. To

obviate such an objection, I have endeavoured to explain how it may be sufficiently applicable to buildings of any construction.

The best mode of constructing hospitals, and buildings of every kind, with a view to their ventilation, with some observations on the management and internal economy of hospitals and prisons, I intend to make the subject of a future Work.

VENTILATION.

VENTILATION consists in changing successively the air of apartments.

The necessity and advantages of a free ventilation have long been universally acknowledged. Powerful appeals in its behalf have been repeatedly made to the public by men of talent and experience, and the fatal consequences of neglecting these, are written on every page of the history of human disease. Is it not strange, then, that an effective plan has never yet

been generally adopted, by which an object so very desirable and necessary might be accomplished?

It is certain, that all the means of ventilation in general use are only effectual in admitting air, while they fall short of the power of giving it free transmission through many places in which it is required.

Is it too much to expect, that a serious and candid attention will be given to the suggestion of any mode, however weak or undigested, for accomplishing an object so vitally connected with existence, and with the happiness of human life?

After describing the chemical constitution of the air, the change it undergoes in respiration, the evil consequences of

living in confined air, and stating the opinions of some of the most experienced and learned writers on these subjects, I shall treat of ventilation by the agency of caloric; its mode of application to hospitals, and the chambers of the sick—to the destruction of contagion, and to the prevention of the spreading of infectious diseases.

Atmospheric air, that invisible, elastic fluid with which the earth is surrounded and enclosed on all sides, is composed of two ingredients, termed gases—one named oxygen, the other nitrogen or azote. The relative proportion which these bear to each other, is about 22 parts of oxygen to 78 of azotic gas by measure, and about 26 of oxygen to 74 of azotic gas by weight.

Air is so essentially necessary to life,

that the subjects of either the animal or vegetable kingdom, when deprived of it, immediately languish and die. A given quantity of it, however, can be breathed only for a limited time; after which, it becomes the most deady poison, and produces suffocation as effectually as the most noxious gas, or a total absence of air. It is, therefore, obvious, that air, in respiration, undergoes a very important change.

Atmospheric air, breathed and retained for a sufficient length of time in the lungs, on being expired, is found to be altogether deprived of its oxygen, and to consist of azotic and carbonic acid gases, combined with a quantity of aqueous vapour. It is not my intention to enter into the controversy how that oxygen is disposed of, whether it unites with the

blood, as some have imagined, or is combined with carbon, to form the carbonic acid, or with hydrogen, to form the aqueous vapour. I only solicit attention to the fact, that air, in respiration, undergoes a certain change, and that having undergone that change, it is no longer fit for the support of animal life.

It is well known, that a land animal would live as long under water as in air totally deprived of oxygen. Even the most imperfect and most cold-blooded animals, such as worms, frogs, and fishes, cannot live in air wholly deprived of oxygen; and, what may appear remarkable, eggs cannot be hatched without a proper supply of this vital gas. Animals the most tenacious of life, as well as the most tender and perfect, when confined in a given quantity of air, all die, sooner

or later, according to the demand of their constitutions for this life-supporting principle. Hence the necessity of changing the air, in all apartments intended for the habitation of men, or animals of any species. Where this precaution has been neglected, fevers of the most malignant and pestilential nature have been frequently generated, by accumulated and concentrated animal effluvia alone.

Nothing is more common than for passengers and crews of vessels to continue healthy and vigorous during good weather, and to become affected with fevers of the worst kind, when obliged, from stormy weather, to confine themselves under closed hatches.

Dr. Lind informs us, that "in a frigate which sailed from North America with a

healthy crew, a fever broke out, before her arrival in England, during very bad weather, which infected a considerable number of the crew, and of which the surgeon's-mate, boatswain, and some others died." "Thus," he remarks, "a seasoned, sound crew, became infected, as it would appear, from the closeness and damp below, occasioned by the hatchway being kept shut."*

He further observes, that "Typhus frequently arises in hospitals, gaols, transport-ships, &c. when due care has not been paid to ventilation. It is evident, therefore, that the effluvia of the living body, having become putrid by stagna-

* It is obvious, from the Doctor's Narrative, that the crew became infected from the accumulated and concentrated putrid human effluvia.

tion, are capable of producing this fever. Putrid effluvia from any other cause, also produce Typhus. Thus, uncleanliness of all kinds is favourable to the production of this complaint; and, on this account, such fevers generally take their rise among the poor, and among them also are most fatal."*

The following extracts from Sir JOHN PRINGLE's Observations on the Diseases of the Army and Navy, will tend still farther to illustrate the subject:—

"The hospitals of an Army, not only

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* Notwithstanding the opinion of Dr. LIND, though such fevers have commonly had their origin among the poor, yet, when communicated to the higher ranks of society, they have been generally, in proportion to the number affected, among that class most fatal.

when crowded with sick, but at any time when the air is confined, and especially in hot, cloudy weather, produce a fever of a particular kind, and very mortal. I have observed the same sort to arise in full and crowded barracks, and in transport-ships, when filled beyond a due number, and detained long by contrary winds, or when the men have been long kept at sea, under close hatches, in stormy weather. Hospital ships for distant expeditions, have, for this reason, been destructive both to the sick and their attendants. This disorder is incident to every place ill aired and kept dirty, that is, filled with animal steams from foul or diseased bodies. Upon this account, gaols, and military hospitals, are most exposed to this kind of pestilential infection."—"The most airy and spacious houses to be found in the neighbourhood

of the camp, were recommended for the better recovery of the sick, and for guarding against infection. Now, the same means will also tend to prevent the hospital fever, as the dysentery is so apt to breed it. On these occasions, it is common to look out for close and warm houses, and, therefore, to prefer a peasant's house to his barn; but experience has convinced us, that air, more than warmth, is requisite. For this reason, not only barns, stables, and granaries, and other out-houses, but, above all, churches, make the best hospitals, from the beginning of June till October. Of this there was an instance in the campaign of 1747, when a large church at Maestricht was applied to that use; and where, notwithstanding above an hundred lay in it, with foul sores, fluxes, and other putrid diseases, for three months together, (during

the greatest part of which time the weather was very hot,) there was no appearance of this fever. We may, therefore, lay it down as a rule, that the more fresh air we let into hospitals, the less danger there is of breeding this distemper. The want of pure and wholesome air can never be compensated by diet and medicine." — "Gaols have been often the cause of malignant fevers; and perhaps no where oftener than in this country."

Lord Bacon makes the following observations:—"The most pernicious infection next to the plague is the smell of the gaols, when the prisoners have been long, and close, and nastily kept; whereof we have had in our time experience twice or thrice, when both the judges that sat upon the gaol, and numbers of those who

attended the business, or were present, sickened upon it and died. Therefore it were good wisdom, that, in such cases, the gaol were aired before they were brought forth."

His Lordship, it is probable, had in view the fatal assizes held in the year 1577, a more particular account of which is given in Stowe's Chronicle, in these words:—"On the fourth, fifth, and sixth days of July were the assizes held at Oxon, where was arraigned and condemned Roland Jenkins, for a seditious tongue; at which time, there arose amidst the people such a damp, that almost all were smothered. Very few escaped that were not taken. Here died, in Oxon, three hundred persons; and sickened there, but died in other places, two hundred and odd."

The following is Sir JOHN PRINGLE'S account of what have been called the Black Assizes, held at the Old Bailey in London:—"In the year 1750, on the eleventh of May, the Sessions began at the Old Bailey, and continued for some days; in which time there were more criminals tried, and a greater multitude was present in the court than usual. The Hall in the Old Bailey is a room of only about thirty feet square. Now, whether the air was at first tainted from the bar, by some of the prisoners then ill of the gaol distemper, or by the general uncleanliness of such persons, is uncertain; but however that might have been, it will be very easy to account for its corruption, especially as it was so much vitiated by the foul steams of the bail-dock, and of the two rooms opening into the court, in which the prisoners were the whole day

crowded together, till they were brought out to be tried. It appeared afterwards, that those places had not been cleaned for some years. The poisonous quality of the air was still aggravated by the heat and closeness of the court, and by the perspirable matter of a great number of people of all sorts, penned up for a great part of the day, without breathing the free air, or receiving any refreshment."

He adds, in a note, "It has been the custom some days before every sessions, to remove the malefactors from all the other gaols into Newgate, already too much crowded."

"At such times, three hundred have been confined within that narrow space; and it is well known how nastily both this, and all the other prisons are kept.

I have been informed, that at those sessions, about a hundred were tried, who were all kept in those close places as long as the court sat; and that each room was but fourteen feet by eleven, and seven feet high. The bail-dock is also a small room taken off one of the corners of the court, and left open at the top; in this, during the trials, are put some of the malefactors, who have been under the closest confinement."—"The Bench consisted of six persons, whereof four died, together with two or three of the council, one of the under-sheriffs, several of the Middlesex Jury, and others present, to the amount of above forty; without making allowance for those of a lower rank, whose deaths may not have been heard of; and without including any that did not sicken within a fortnight after the sessions."

In a second note he states, that " The Bench consisted of the Lord Mayor, three of the Judges, one of the Aldermen, and the Recorder. Of these died Sir Samuel Pennant, Lord Mayor; Sir Thomas Abney, and Baron Clarke, Judges; and Sir Daniel Lambert, Alderman. It is remarkable, that the Lord Chief Justice and the Recorder, who sat on the Lord Mayor's right hand, escaped, while he himself, with the rest of the Bench on his left hand, were seized with the infection; that the Middlesex Jury on the left side of the court, while the London Jury opposite to them, received no harm; and that, of the whole multitude, but one or two, or at most a small number of those who were on the Lord Mayor's right hand, were taken ill."

" Some unacquainted with the danger-

ous nature of putrid effluvia, have ascribed both this circumstance, and the sickness in general, to a cold taken by opening a window; by which, a stream of air was directed to the side of the court on the Lord Mayor's left hand. But it is to be observed, that the window was at the farthest end of the room from the Bench, though the Judges suffered most. Nor could the kind of fever, or the mortality attending it, be attributed to a cold; it is, therefore, probable, that the air from the window directed the putrid streams to that part of the court above-mentioned. This, indeed, must be granted, that all septic particles passing into the blood, become more active and fatal, if the infected person catches cold, or by any accident suffers a stoppage of perspiration; for a free perspiration seems to be the chief means by which

the blood is purified from any infectious matter."

Such is Sir JOHN PRINGLE's account of these fatal Assizes; and such was his opinion of the cause of the disastrous event. The fact appears to have been decidedly this, the open window at the farthest end of the room from the Bench on the right hand side of the court, admitted a current of air which swept across the court to an open window on the left hand side of the Lord Mayor —carrying with it all the putrid exhalations arising from the prisoners, and marking its course with contagion and death.

"The contagion by which Typhus Fever is produced," says Dr. LIND, "is generated in three ways; the first of

which is the confinement of the healthy animal exhalations in a crowded and ill-ventilated place."

Mr. Howell, and others, who escaped from the black hole at Calcutta, were seized with Typhus Fever.

Dr. Chisholm, in his observations on the remote causes of fever, says, "The second proceeds from human effluvia, arising from healthy persons, but, from the peculiarity of circumstances in which they are placed, in a state of morbid concentration, are capable of generating a principle similar to that produced by infectious and pestilential effluvia."

Mr. Hunter, in his excellent work on the Lues, has given reason for believing that new diseases are continually produced

among the poor of great cities, from the want of cleanliness and proper ventilation.

Dr. FORDYCE, and others, state, that many brute animals are subject to Typhus, when crowded together in ill-ventilated places. It has been observed to break out among hogs and sheep.

It is very common to find mild febrile attacks among the poor, apparently originating from cold, or other causes, becoming contagious in their course, in consequence of the confined and dirty situations in which the patients lie.

"I have known a nervous fever," Dr. FERRIER observes, "which was putrid also in many instances, preserved in a small town for almost two years, among the poor alone."

One of the most satisfactory cases of this sort was observed by Dr. Heysham at Carlisle.

In 1779, a fever of the nervous kind raged in that city, which did not seem to be introduced from any neighbouring place. Dr. Heysham, with great industry, traced its origin to one of the gates, which was tenanted by five or six poor families.

I conceive it unnecessary to adduce more facts, corroborative of the important truth, that accumulated and concentrated animal effluvia are sufficient to produce diseases of a most malignant and pestilential nature; or to give more references, to show that such has been the opinion of the most experienced and learned writers on the subject.

It is a fact, established by the experience of ages, that the most destructive diseases with which our cities and towns have been visited, have generally had their origin either among the poor, whose houses, besides being crowded, are the abodes of all kinds of filth and wretchedness, and destitute of every means of ventilation; or in barracks, poor-houses, hospitals, prisons, ships, boarding-schools; or in places which are filled with animal effluvia, from a number of persons being confined or collected together.

The necessity, therefore, of changing the air in all such situations is too obvious to require comment. The best mode by which this is to be effected, is next to be considered.

The science of Natural Philosophy has

taught us, that the incumbent weight of the aerial fluid with which we are surrounded is very great, though not obvious to our senses—that all its motions are the result of gravitation—that its gravity must necessarily vary in proportion to its rarefaction or condensation—that the chief agent, yet discovered in Nature, by which it can be rarefied, is caloric—that its rarefaction or condensation depends on the presence or absence of this agent—that in proportion to the quantum of caloric which exists in a place, in the same proportion will the air be rarefied; and, on the contrary, in proportion as caloric is removed from a place, in the same proportion will the air be condensed. Hence we find, that if the temperature of a place be equable, the air being equally pressed on all sides, will consequently be perfectly still. But if a portion of caloric

be introduced, the air becomes thereby rarefied, and being lighter than the surrounding medium, ascends, when the more condensed, bearing a greater degree of pressure, immediately rushes in where it meets with the least resistance, and assumes the place of the ascending air.

All winds are but air in motion, and are caused chiefly by rarefaction, through means of heat. One portion of the atmosphere being rarefied, ascends, while the surrounding, and more condensed air, rushes in to supply its place. The earth's diurnal rotation, indeed, may by some be considered to have a slight effect in producing a current, or in giving it increased impetus; the attraction of the sun and moon may produce atmospheric tides, fluxes, and refluxes; but the chief agent in all the motions of the air is caloric.

Having, then, discovered an agent, by which we can produce a current of air when we choose, conduct it in any direction we please, and obtain a sufficient supply of it from every quarter, we ought to avail ourselves of the use of that agent, in changing the air of apartments; and in giving to air, in every situation, and under every circumstance, a free and uninterrupted circulation.

All apartments in which a fire is kept constantly burning require no other means of ventilation, provided the apertures through which the air is to be admitted into the apartment be properly situated, and the degree of draught, or suction, in the funnel be proportioned to the necessity of the case.

Those apartments in which this is in-

admissible or inconvenient, should, by means of ventilating or conducting tubes, communicate with an open fire, or close stove, at the most convenient distance.

At the end of the apartment, opposite to these ventilating tubes, or to the fire, or most remote from them, should be placed the apertures through which the air is to obtain admission. These may consist of lifting windows, doors, ventilators, or of conducting tubes arranged for that purpose. On lighting up the fire, its heat rarefies, and causes the immediate ascent of the air in the funnel, flue, or stove; to supply the place of which, the air of the apartment being more dense, immediately rushes through the fire. The egress of this produces a similar rarefaction in the air of the apartment; consequently, the pure air from without, in-

stantaneously rushing through the apertures, assumes its place. Thus a current is established, by which the vitiated air is not only immediately carried off, but its place regularly supplied with pure air.

From this view of ventilation, by the agency of caloric, its mode of application to hospitals, and to every place requiring it, will be easily understood. It is of no importance whether the form of the building be ancient or modern. In an hospital, the common kitchen, with a fire constantly burning in it, should be, as is usual, on the ground floor. A tube of from six to twelve inches in diameter, for the purpose of admitting a sufficient supply of pure air to every apartment, opening without, and at that side of the building from which the purest air is likely to be obtained, should pass through some place

so contiguous to the fire, that the air which it conveys might be heated from 60 to 100 of Fahrenheit, according to the magnitude of the building which it is designed to heat. The tube thus heated, passing along, and ascending, should send off a communicating branch to every apartment in the building. Each of these communicating branches being again subdivided into three smaller tubes, should open into one end of each apartment, about a foot from the floor—one in each corner, and the third in the middle.

A second tube, of the same dimensions, for the purpose of admitting pure air in the warm Summer season, opening in like manner outside the building, should unite with the former tube, at a proper distance from the fire, and before it gives off the first communicating branch. An air-tight

sliding valve should be placed in each of these, at some distance from their point of union. These valves are to be used for the purpose of cutting off all communication with the cold air in Winter, and the hot in Summer. This part of the tube should be made of earthenware, or some such inoxydizable substance. It is not very important, however, of what material it be constructed, provided it be perfectly air-tight; as no metal which might answer the purpose, at any of the degrees of temperature pointed out, is likely to be acted upon, so as to produce any disagreeable smell, or to be oxydized, so as to decompose or at all deteriorate the air which may pass through it. The air might be heated equally well by causing it to pass through a tube kept constantly surrounded with hot water. As this plan, however, would be attended

with some additional labour, and as it does not seem to possess any decided advantage over the other, I prefer the former.

Thus, then, has been described the plan, by which not only pure air, but genial warmth, may be conveyed into every part of a building. The following is the means to be employed, for causing air to circulate through the apartments, and for carrying it off after it has been vitiated :—

Two tubes, from six to twelve inches in diameter, according to the size of the apartment, should open, one about three feet from the floor, the other at the ceiling, and both tubes exactly in the middle of the end of each apartment, opposite to that at which the heating

tubes entered. These tubes should terminate in one common trunk, extending from the upper to the under floor of the building.

This trunk, after arriving at the under floor of the building, and extending a few feet horizontally, should pass, in an ascending direction, up through the fire, and then rise perpendicularly, to discharge its contents either into the funnel, or at the top of the building. That I may be the better understood afterwards, I shall call these, ventilating tubes—the former, heating tubes.

The beds of the patients should be arranged along the middle of the wards, in a direct line between the heating and ventilating tubes, and not along the side walls, as is generally the case. A wire-

net screen of a close texture, placed about four or six inches from the wall, rising from the floor four feet high, and closed in at the top, should extend across all that end of the ward out of which the heating tubes open, so that the currents may be spread equally over every part of the ward.

Thus, then, it will be seen, by referring to the plates, that the currents of air, throughout their whole extent, converging as they pass along, would not only sweep and ventilate every part of the ward, but completely repel the contagious exhalations, prevent them from spreading to either side of the apartment, and carry them with them in their course; so that the medical and other attendants might pass and repass, to the windward of the patients, up or down either side of the

GROUND PLAN.

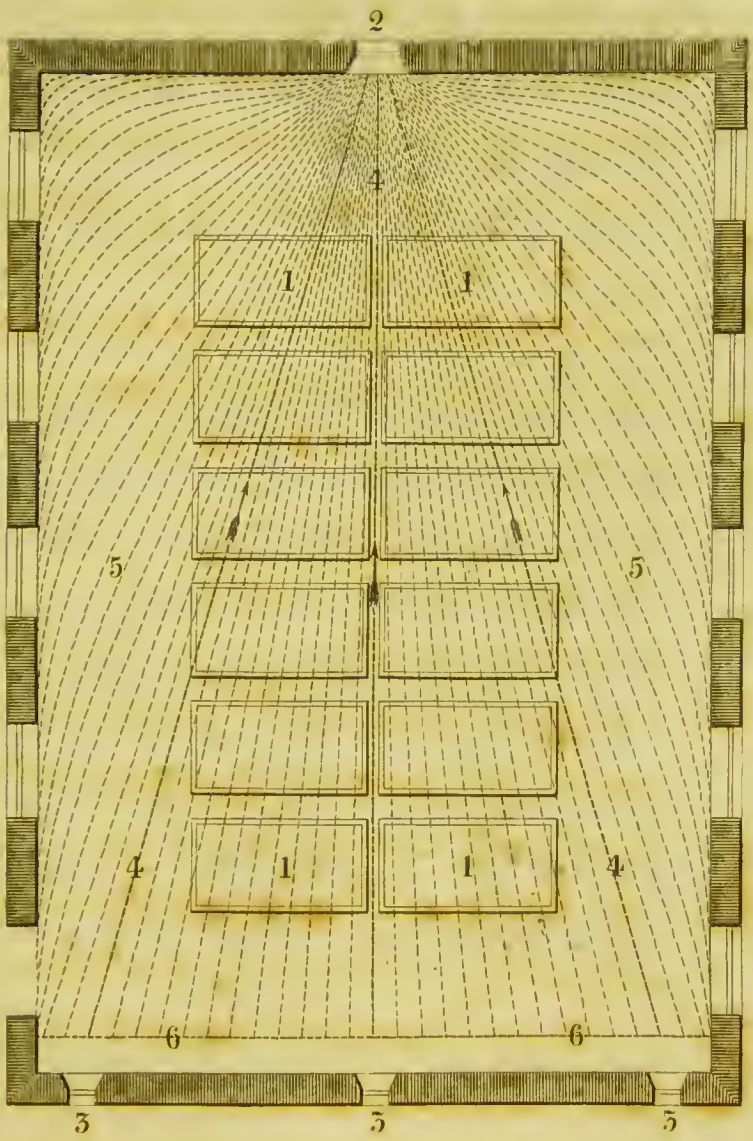

Fig. 1. *Beds ranged along the middle of the ward.*

__2. *Ventilating tube.*

__3. *Heating tubes.*

__4. *Direction of the currents to ventilating tube.*

__5. *Passage round for medical & other attendants.*

__6. *Wire-net screen.*

ward—give every necessary attendance to the patients at the ends or sides of the beds, without the slightest danger of inhaling the least portion of contaminated air.*

Not only would the intense heat constantly applied to the ventilating tube, in its passage through the fire, act as an exhausting power on the tubes, producing such a degree of suction in the apartment as to cause the pure air to flow in freely through the heating tubes, but the contagious exhalations, immediately on arising from the bodies of the patients,

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* Should a patient require any extraordinary attendance, his bed, the stead of which should be always made of cast-iron, may be drawn out on its castors into the passage, and the attendant place himself at its windward side.

would be wafted in the currents to the ventilating tube, by which they would be carried through the fire, and discharged at the top of the building. In passing through the intense heat, the air would be thoroughly purified from all impregnation, the contagion completely destroyed, and rendered incapable of communicating the disease to any individual.

Dr. Lind has observed, that, from long experience, he was convinced that even the simple heat of a close, confined fire, or the heat of an oven, is a destroying power, which no contagion whatever can resist. The same principle was acted upon by Sir James M'Grigor and Dr. Frank, during the late Peninsular war, particularly when a dreadful fever prevailed after the retreat of Sir John Moore's army from Corunna.

All parts of private houses, and more particularly bed-chambers, ought to be both heated and ventilated, on the same plan as that recommended for hospitals. In cases of disease, where this cannot be conveniently accomplished, the mode should be imitated as nearly as possible, by keeping a fire constantly burning in the chambers of the sick, and placing the beds of those labouring under febrile, or contagious diseases, as nearly as possible in a straight line between the fire and the apertures through which the air obtains admission. These may be doors or windows. If the windows be not very close, as much air, while the fire continues to burn, will generally enter round the framings, or under the door, as will answer every purpose; if not, the windows may be pulled down, about two or three inches from the top. The fire-

place, in the Winter season, should be closed in front, down only to the first bar of the grate, so that the heat may be communicated to the apartment; in Summer, it should be closed down, to within a few inches of the ash-pit, to prevent any heat from radiating into the chamber.

It may be necessary to mention, that the fire-place may be closed by means of a moveable metallic plate, or screen, which may be taken away, or adjusted as circumstances (such as adding fuel, &c.) may require. The writer's object in recommending the fire-place to be so closed in front, is, that all the air of the chamber conveying the contagion, or impregnated with it, may pass up through the fire into the funnel. Though the Author has suggested the propriety of

subjecting contagion to the action of fire, both in hospitals and in private houses, yet, he is of opinion, that after it has been discharged at the top of a funnel, or chimney, and has been mingled with the atmosphere, it becomes too much diluted to be likely to produce disease.

It is surely unnecessary to observe, that in all cases of disease, especially such as are of a febrile or contagious nature, the curtains should be removed from the beds, and the most scrupulous attention paid to cleanliness.

In the houses of the poor, it may be possible only to imitate the plan recommended. Provided the windows should not have been made to lift, the air should be freely admitted through them by breaking out a pane. If there be no

fire-place in the patient's room, his bed should be removed into an apartment in which a fire is burned, and placed between it and the windows or door.

The happy consequences resulting from a scrupulous observance, in public and in private practice, of the means suggested, would exceed the most sanguine expectation. By the use of such a method, contagion could be totally eradicated from any hospital or private house, and a contagious disease would never be communicated to a second individual. The same mode of preventing the propagation, or spreading of diseases, would, besides, not only be applicable without removing the patients from their apartments, as is indispensably necessary in most other plans yet discovered, but would be highly useful

in facilitating the cure of all contagious diseases.

There would, at the same time, be no danger of those disadvantages attending the constant burning of a fire in the apartments of the sick, described by Sir G. O. Paul, in an Essay communicated to the Society for the Encouragement of Arts, &c. The following are that writer's observations:—"When the doors are shut, and strong fires made, these will inevitably attract the currents of air inwards and towards them from all openings; and should patients be situated in their course, the effect cannot fail to be injurious." These supposed evils are, however, altogether imaginary; for who has ever heard of any one suffering injury from cold, either sitting or lying in bed, in a warm room, with a good fire burning?

True, while the fires continue to burn, there will be currents of air from both door and windows; but if they be shut close, there will be no fear of the currents being so strong as to endanger the health of any of the inmates. Sir G. O. Paul has also stated, that, "As the windows are generally closed in the night, (the most important time for ventilation,) no other change of air takes place, but what is effected by the open fires, which, while supplied immediately from the middle region, are constantly consuming the best air of the room." How he was led to form such an erroneous opinion, I cannot conceive; for, that the fire in the grate possesses any power of selecting the good air from a room, and leaving the bad, is quite absurd; as the determination of the currents, conveying both good and vitiated air to the fire, in every case,

depends on the cause already pointed out. It is a fact, that the air on coming into contact with the fire, will be immediately decomposed; but it is equally true, that, while the fire continues to burn, the air so vitiated cannot return into the chamber, but must ascend, to be discharged at the top of the funnel; and it is not till combustion ceases, that the air of the apartment undergoes any deterioration. It is certain, that every part of the room will contain as pure air after the fire has continued to burn for twelve hours, as when it commenced. The chamber is like a cask full of holes in the midst of a river. As, when the water flows out at the one side of the cask, more flows in at the other, so, when the air of the chamber flows into the flue, or chimney, the pure surrounding air, from without, forces its

way into the room through every aperture.

On perusing the following extract from the writings of that experienced and justly celebrated practitioner, Sir JOHN PRINGLE, the reader may form some opinion of what were his ideas of the necessity of ventilation, and of the inadequacy of the means commonly in use for effecting that object:—"As to the disposition of hospitals, with regard to preserving the purity of the air, the best rule is to admit so few patients into each ward, that a person unacquainted with the danger of bad air, might imagine there was room to take in double or triple that number.

It will also be found a good expedient, when the ceilings are low, to remove some part of them, and to open the garret story

to the tiles. It is surprising in how few days the air will be corrupted in close and crowded wards; and what makes it hard to remedy the evil, is the difficulty of convincing either the nurses, or the sick themselves, of the necessity of opening the doors or windows at any time for air. I have generally found those wards the most healthful when, by broken windows, and other wants of repair, the air could not be excluded."

However useful the suggestions of Sir JOHN PRINGLE may have been for the regulation of hospitals ventilated in the usual way, the precaution would be altogether unnecessary in those ventilated on the plan now proposed, as there would be no fear of overcrowding with patients the wards of an hospital so ventilated. No matter how closely they are placed

in the rows of the wards, on the plan directed, provided their bodies are not in actual contact; as the injurious heat, vitiated air, and impure exhalations, immediately on being disengaged, would be carried by the currents to the ventilating tubes. There would, therefore, be no danger of the air becoming corrupted, as happened under the care of Sir John, and economy would be greatly promoted; as the necessity of leaving one-half, or two-thirds of each ward unoccupied, as he was obliged to recommend, would be entirely removed.

The plan would, besides, obviate the inconvenience of having to open either door or windows at any time for air, and would completely do away with the disagreeable necessity of having to contend with the ignorance and prejudices of

either the patients or nurses; for, while the fire would continue its operation on the ventilating tubes, it would baffle all their ingenuity to exclude the air from their apartment.

The degree of draught in the ventilating tubes may be increased or diminished, according to the necessity of the case; by which means, the air of an hospital ward, or a prison cell, may be rendered as salubrious as that on the top of a mountain.

It is well known that, in this climate, many diseases are more prevalent, and assume a more malignant type in Winter than in Summer; that the mortality invariably bears a proportion to the severity of the season; and that there is much more medicine used in Winter than in

Summer. Hence it would appear, that cold is not only conducive to the production of diseases, but being often the exciting cause, operates materially against their cure. It would, therefore, be a matter of the greatest importance, if those who have the management of hospitals, or the care of the sick in private practice, could have it in their power to regulate the temperature of every apartment in which either the diseased or convalescent are confined. For, though there is a certain period, in some diseases, in which external heat would be decidedly injurious, yet there is a stage in every disease, in which cold air would not only be disadvantageous, but highly dangerous.

On the plan of vetilation suggested in this treatise, it will be obvious to every

one, that, by the agency of a single fire, contagion can be completely destroyed—an entire hospital, private house, or building of any kind heated, and more thoroughly ventilated in every part, than by any means which have ever yet been employed. It is not only admirably adapted to the apartments of those labouring under febrile and contagious diseases, but it would also be a most effectual means of removing those inconveniences, arising from the breathing of a number of persons in confined situations. The universal adoption of such a plan would be attended with the happiest effects. It would be a great saving of human life and public property; while it would avert much of the misery and sufferings of mankind.

It is surely unnecessary to employ

arguments to enforce attention to any means calculated to prevent, or retard, the ravages of fever. Melancholy experience has long since proved it to be one of the most desolating scourges that visit our world. Cruel as the grave, it spares neither age nor sex—the poor and the rich, the active and the indolent, the youth and the man of gray hairs, fall indiscriminately before it. Dark and sorrowful indeed are the pages which record all the melancholy details in the history of this bitter and fatal malady.

Shall I awake the painful recollections of those whose most valuable friends have been, by fever, hurried to a premature grave? Shall I bring to their recollection the loss of indulgent parents, beloved husbands, or endeared relations? Or shall I recite the names of the

Ministers of Religion, and Physicians, who, devoted to the best interests of society, have fallen victims to fever, in their benevolent exertions to alleviate the sufferings of those labouring under it? Such facts make an irresistible appeal to humanity; and the best interests of society are intimately connected with the most improved manner of treating fever, and of destroying and preventing the diffusion of contagion. I have no doubt, therefore, that these observations will meet with that attention from an enlightened public, which the importance of their subject demands.

VENTILATION OF SHIPS.

It has been already proved, that wherever animal life is supported, a change of air is required; and it must be admitted by all, that there are few situations in which men, or animals of any other species, can be placed, where a change of air can be more necessary than in ships.

In ships ventilated in the usual way, however, it has often become necessary, for the purpose of shutting out a more destructive element, to exclude that on which life itself so absolutely depends.

It is, therefore, by no means uncommon to see a number of dead bodies of animals, such as horses, oxen, &c. cast out of a ship on her arrival in port after a stormy passage, which animals have been destroyed in consequence of excluding the air from them, by nailing down the hatches.

For the ventilation of ships, many plans have been invented; the best of which at present in use, appears to be the ventilating sail. This, however, from obvious reasons, will be found quite inefficient in calm weather, the most important time for ventilation; and it is not less obvious that it will be equally useless in a storm, or in rough weather, in the midst of an agitated sea, when every part of a ship must necessarily be secured from the waves. The object of these observations,

therefore, is to point out a mode of ventilating ships, which will operate equally well in all kinds of weather, and under every circumstance.

For this purpose, a communication should be established between every apartment under deck, and the common fire, or close ship stove, by means of tubes, of a magnitude proportioned to the necessity of the case. A tube, for the purpose of supplying every apartment with pure air, (if in cold weather or climates,) should pass, in an ascending direction, through a compartment connected with the fire, and heated by it, or up through a boiler or cistern, kept constantly surrounded with hot water, so that the air supplied to the under-decks of the ship may be heated to the proper temperature. The tube, after being thus heated, and ascend-

ing for about two or three feet, should pass along a few feet in a horizontal direction, and then descend under deck, dividing into different ramifications, sending off a communicating branch, or branches, to open into one end of every apartment in the ship. Pure air, and, in cold weather and climates, genial warmth, may be in this way conveyed into every part of a vessel. This tube should be so constructed, that all communication with the heat could be cut off when necessary. This is to be effected by making all the part which projects above deck moveable, so that it may be taken away or adjusted as circumstances may require. When it becomes necessary to take away the moveable part of the tube, another should be fitted to, which should ascend about three feet above deck, where it should be curved, and descend about a

foot, to prevent the waves, in rough weather, from passing into the vessel. Another series of tubes, opening at the end of each apartment, opposite to that at which the former tubes entered, taking the most convenient course to the fire, should, before entering it, unite in one common trunk, which should pass up through the common fire, or close ship stove. The intense heat thus constantly applied, would produce such an exhausting power on this tube, as not only to solicit a great degree of draught through the former tubes, causing the pure air to flow freely into every part of the ship, but would also excite a current through every apartment, which would as effectually carry the air off again after becoming vitiated.

The principle and the mode of operat-

ing of these tubes, have been sufficiently explained in the observations on the ventilating and heating of hospitals. On the plan described, all parts of a ship may be heated, and as thoroughly ventilated, as any apartment in an hospital or private house. In stormy weather, when the decks of a ship must of necessity be closed, the fire and ventilating tubes would perform a service which could by no other means be obtained.

Were the mode of ventilating ships, recommended in the foregoing sheets, generally adopted, it would be no longer necessary for Government to restrict the number of persons conveyed in passenger vessels; because, in ships so ventilated, as many men, or animals of any other species, as could be placed together, could be carried with perfect safety to

any part of the globe. Neither would there be any danger of such an accident occurring, as that which happened about four or five years ago at Para, in the Brazils, where 276 men were confined over night in a ship, by nailing down the the hatches, of which number, 272 were found dead next morning. There can be no doubt whatever, that the death of those persons was caused by the want of a proper supply of pure air.

Besides, by establishing the ventilating tubes at each extremity of the hold, the putrid exhalations arising from the decomposition of the bilge water, would be effectually carried off, by which means, sailors, in a tropical climate, would be preserved from that awfully destructive disease, alike the terror and the scourge of mankind, well known by the name of

vomito prieto, or black vomit. Of what vast importance, then, would it be to this most useful class of men, were such a mode of ventilating acted on in his Majesty's ships of war, in transport, passenger, and hospital ships, &c.

Seamen are a class of men valuable and enterprising. The best interests not only of the commercial, but of the political world, are so intimately connected with their health, their vigour, and their efficiency, that these observations should commend themselves most especially to the serious consideration of the Lords of the Admiralty.

VENTILATION OF MINES.

Miners are another devoted class of men, whose health and happiness are sacrificed to the public good. Though they have enjoyed the advantages of many useful discoveries, yet, for their comfort and safety, much still remains to be done. There are certainly no human beings in existence, whose lot is more gloomy, more abject, or more miserable.

Neither can any class of men have stronger claims on the humane exertions of the philosopher, the physician, or the

scholar, to devise a plan by which their danger may be lessened, and their condition meliorated. The rapid and gigantic strides which scientific improvements have made during the last century, are truly astonishing. It is not, however, less surprising, that more has not been done to lessen the misery of the unhappy beings employed in mines; the horrors of whose condition have certainly been much imbittered by the impurity of the air in which they are obliged to breathe.

The mode of ventilating by the agency of caloric, suggested in these observations, applied to coal and other mines, would be found not only effectually to defend them from the explosion of inflammable gases, but would tend materially to improve the circumstances of their situation, by affording them a pure atmosphere to

breathe in, than which nothing could be more essentially necessary to health.

For this purpose, a tube, of dimensions proportioned to the extent of the excavation, should extend from the extremity of the pit to the surface, where it should pass up through a fire kept constantly burning; or, after rising two or three feet above the surface, let it bend along a few feet horizontally, and then bend directly upwards.

A kind of grating should be fitted into this tube a little above the last bend, for the purpose of holding a fire, to be kept constantly burning; the tube extending two or three feet above it. At the under part of this bend of the tube, a receptacle for the ashes or cinders should be formed, from which they could be discharged

through an opening, which should be closed by an air-tight sliding bottom. While this moveable bottom remains fixed and air-tight, the air of the pit will make its way up through the fire with great force. The latter plan, however, seems to be something more complicated, and does not appear to possess any advantage over the former, as both operate exactly on the same principle; for the sake of facility, therefore, the former method may be preferred. The following plan might operate equally well:—Let a funnel be built as close as possible, and into the top of it let a tube be solidly impacted, and kept constantly surrounded with fire, or let a fire be burned in it, as before recommended. Sir Humphry Davy, in the year 1815, discovered that carburetted hydrogen, mixed with atmospheric air, in the proportion which is most explosive,

and then ignited, will not set fire to another portion of the same mixture, separated from it by a sieve of small wire, the meshes of which amount to two hundred and fifty in the square inch. The current, therefore, should be caused to pass through a wire sieve of this description, a few feet before it comes into contact with the fire, for the purpose of preventing an explosion of the air of the pit.

A communication of some kind for the purpose of supplying every part of the excavation with pure air, such as those shafts or boxed passages which miners use, should be established between the atmosphere and the pit, at the end opposite to that at which the ventilating tube entered, or most distant from it, provided the opening at which the coals are dis-

charged be not so situated. The pure atmospheric air, flowing freely through this passage into every part of the pit, would be carried in a continual current to the ventilating tube, or funnel, through which it would ascend with great force, and be discharged at the surface. By these means, the vitiated air, and impure exhalations, would not only be immediately carried off, and their place supplied with pure air, but the inflammable gas would ascend in the current, with rapidity, to the surface through the ventilating tubes. Fires and candles might then be burned below with safety, and the miner breathe as pure an atmosphere as he could enjoy on any part of the surrounding surface.

The plan of ventilation here suggested may be found to yield greater safety,

and to be a blessing to miners more valuable than Sir HUMPHRY DAVY'S safety-lamp, for the invention of which he has very justly obtained so much celebrity.

The safety-lamp has undoubtedly been the means of averting much calamity, and many fatal accidents; yet, notwithstanding its efficiency, we are yearly shocked with the accounts of melancholy catastrophes from the explosion of air-damp in coal and other mines, and the consequent loss of many lives. It is, therefore, unnecessary to adduce more arguments, to inculcate the necessity of some efficient plan being adopted, or to enumerate any additional advantages to be derived from it, but most earnestly to entreat that Government, or the proprietors of coal and other mines, would not only give this plan a most serious and impartial con-

sideration, but let it have a full and fair trial; and if they should think it likely to be successful, have it immediately put into execution.*

Barracks, poor-houses, lunatic asylums, churches, manufactories, assembly-rooms, school-rooms, theatres, court-houses, and

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* Since writing the above, I have been informed that the coal mines in England and Scotland are ventilated on a plan somewhat similar to that I have recommended. If this be the case, to secure the miners from the dangerous consequences of an explosion of inflammable gas, it is only necessary, by the strength of the fire, and the judicious position, distribution, and extent of the apparatus, to give sufficient force to the currents of air through the different parts of the pit. Should any part of the excavation not come sufficiently within the range of the currents, the inflammable gas, and other impure or unhealthy exhalations should be regularly drawn off to the fire, from even the utmost extremity of these blind passages, by means of tubes arranged for the purpose.

all places of confinement or crowded resort, should be both heated and ventilated precisely on the same plan and principle as that pointed out for hospitals. The common kitchen fire, (besides answering for all the culinary purposes of the house,) with a communication between it and all the different apartments, by means of tubes arranged in the manner pointed out for hospitals, would, at a much less expense,* and with much less risk of damage by fire, heat and more thoroughly ventilate, in every part, any of the above establishments, or buildings of any kind, than any other means now in use. The

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* Heating prisons, barracks, or poor-houses, by one fire, would be a great object of economy, which is certainly a great desideratum in institutions supported by public contribution, or at the public expense.

apartments would thus become not only much more comfortable for habitation, but the diseases peculiar to them would cease to be known.

The malignant fevers which often break out with great virulence in poor-houses, manufactories, school-rooms, and all such crowded situations, and threaten desolation to whole districts, would entirely disappear. This is satisfactorily proved by that fatal disease making its appearance more frequently in Summer than in Winter, in school-rooms heated by an open fire, which is only kept burning in the Winter season; being, by the agency of the fire, better ventilated, though often very imperfectly, owing to its injudicious position, and the apertures through which it is supplied with air. It would be peculiarly useful in manufactories, as those

who work in them immediately become pale, blanched, and emaciated, and drag out a miserable existence from the heat and impurity of the air in which they are obliged to breathe.

VENTILATION OF PRISONS.

Bentham's plan of prison inspection seems to be very good, and appears worthy of being generally adopted. It is evident, however, that he has had no idea of the most important part of prison economy—the method of diffusing warmth and free ventilation. This subject, therefore, demands our most serious attention; but as, in the foregoing observations, I have expatiated at sufficient length on a plan of ventilating and heating recommended for hospitals, I consider it unnecessary to say more on that subject here.

Prisons on the plan pointed out, could be heated, and much better ventilated in every part, than by those open holes which BENTHAM seems to recommend. Were all prisons so ventilated, that hideously formidable and fatal disease, commonly known by the name of gaol-fever, would cease to have a name or a place in the catalogue of diseases. The safety and security of the prison would, besides, by the same plan, be greatly increased. Were Judges and Lawyers, and the Noblemen and Gentlemen who compose the Grand Juries of the different Counties, aware of the danger which they incur in attending on the trials of prisoners brought out of ill-aired and crowded cells, they would take special care to avail themselves of the most efficient plan of ventilating every part of prisons.

The cases which have been already related, pointing out the direful consequences of neglecting this very necessary precaution, should be a sufficient admonition to those on whom the duty devolves, of having the air sufficiently and regularly changed in every cell in a prison. The Government of the country incur a greater degree of responsibility in the management and in the state of prisons, than in any other part of legislation.

In most other places, the inmates voluntarily subject themselves to all the hardships of their situation; but the prisoner is arrested, dragged and forced, against his will, into a place of confinement, or dungeon, exposed to all the horrors and direful influence of a malignant and fearfully destructive disease, from which he has no power whatever of escaping. And though

many of those who have been so confined, were worthy of the most horrid and ignominious death, yet it has often happened, that many persons, who, if they had survived a trial, would have been honourably acquitted of the charge which constituted the ground of their arrest, have fallen victims to an executioner, whose mandate is irresistible, and from whose decree their innocence afforded them no plea for appeal.

FINIS.

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